GEO ENERGIE SUISSE

Schweizer Kompetenzzentrum
für Tiefengeothermie zur
Strom- und Wärmeproduktion

ein Unternehmen von

Technical Note:

Comparing the risk of induced seismicity to OPAM, to the DHM Project Basel and to the risk of fire in the community of Haute-Sorne and surroundings

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Summary

Aim of this study was to compare the risk of induced seismicity for the geothermal pilot project in the community of Haute-Sorne to other risks faced by society. Risk is compared to the stimulation of the Deep Heat Mining project in Basel, the statutory order on hazardous incidents (OPAM) and the risk of fire. The risk of fire was chosen, because it is known to the general public and is faced by every person every day. It is shown, that the risk of induced seismicity is significantly lower compared to the Basel project and is also too low to fall into OPAM categories. In comparison to the risk of fire, the risk of induced seismicity, calculated under conservative assumptions for an aleatory variability of +/- 2 intensities, is a factor of 5 -150 lower for damages above 1Mio. CHF.

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1 Introduction

Geo-Energie Suisse AG has conducted various risk studies (Baisch et al., 2013, Alcolea & Bethmann, 2013, Bethmann & Zingg, 2015) to quantify the risk posed by induced seismicity in the community of Haute-Sorne. It was demonstrated, that the risk does not fall into the categories defined by the statutory order on hazardous incidents (OPAM) and based on the judgment criteria within, it is therefore acceptable. However, the question remains how to put the risk of induced seismicity, which is dominated by minor damages (non-structural) into perspective.

For the purpose of assessing the acceptability of risks related to induced seismicity, it is helpful to compare it to other technical risks that humans face every day. One study, that compares different risks in Switzerland from a viewpoint of civil defense, is the KATARISK study. From the different risks investigated within the study we pick the risk of fire, because it is a permanent risk and the shape of the risk curve is similar to the one of induced seismicity. Because the presented fire curve is calculated for Switzerland, it has to be scaled to the radius of influence for induced seismicity. In addition risks are also compared to the risk calculated for the Deep Heat Mining Project in Basel, to show a comparison to a project where risks were too high to continue the project and to the statutory order on hazardous incident (OPAM), a tool used to judge the acceptability of technical risk posed by chemical plants. In the following we present the comparison of risks and the method of scaling used.

2 Risk of fire

Data given by KATARISK of 1'200 Mio CHF losses per year in Switzerland differs in comparison with information of the BFB ('Beratungsstelle für Brandverhütung') of 600 Mio. CHF per year. Both sources of information do not mention the sources for their data and how the data was processed. One reason for the difference might be that in the first case some indirect losses are also taken into account and in the latter case only damages covered by insurance are considered, or that high loss - low probability events are not considered by the BFB. Therefore, to verify KATARISK, the loss curve of fire is plotted against data from the yearly loss reports published by the 'établissement Cantonal d'assurance immobilière et de prévention' of the Canton Jura (list see Appendix B). Publicly available data for the Canton Jura spans an 8 year time interval, including 131 incidents, the highest loss being 1.4 Mio. CHF. As can be seen in Figure 3 the loss curve for the Canton Jura is within factor 2 of KATARISK for loss values <400'000 CHF. Above 400'000 CHF the risk for Canton Jura decreases more rapidly compared to KATARISK. This might be an effect of the short time interval of 8 years (published data), for which data is limited and therefore not representing a sound basis for statistical completeness.

However, to accomplish the fact that other sources show a lower risk of fire compared to KATARISK, a shaded area under the KATARISK study is plotted, that divides KATARISK by a factor of 2.

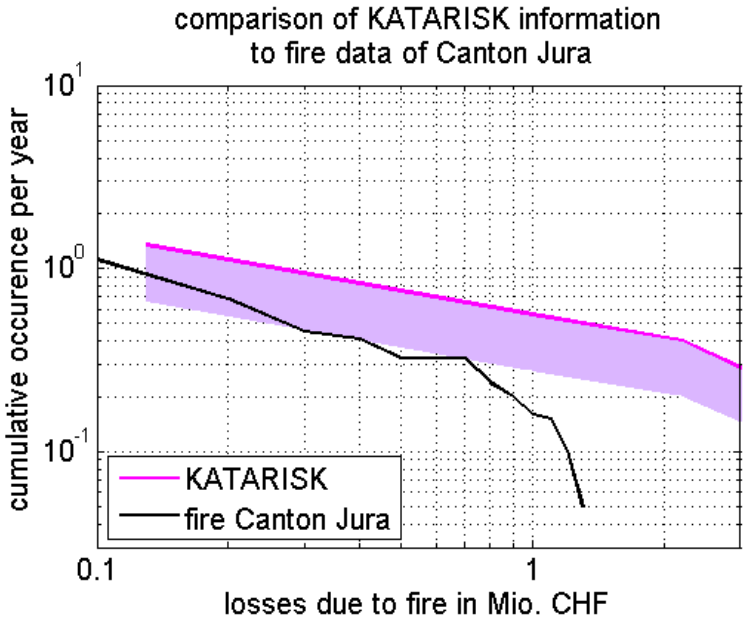

Figure 3: Comparison of KATARISK loss information to cantonal statistics. Because KATARISK data differs in comparison to cantonal insurance and BFB data, KATARISK data was divided by 2 (area under KATARISK curve). As (published) cantonal data is limited to a time interval of 8 years, damages above 400'000 CHF might be underrepresented.

3 Comparison of risks

Figures 4 to 8 show risks related to induced seismicity during stimulation of the geothermal pilot-project in Haute-Sorne compared to the risk of fire, to the DHM project Basel and to OPAM thresholds (Figures 4 to 8 generated as per request of the authorities of Canton Jura). Considering losses above 1 Million CHF, the societal risk of induced seismicity due to stimulation of the underground in the community of Haute-Sorne is significantly lower compared to the risk caused by fire and also significantly lower compared to the stimulation of the Deep Heat Mining project in Basel. It is also shown, that risk of induced seismicity does not fall into OPAM risk categories[1].

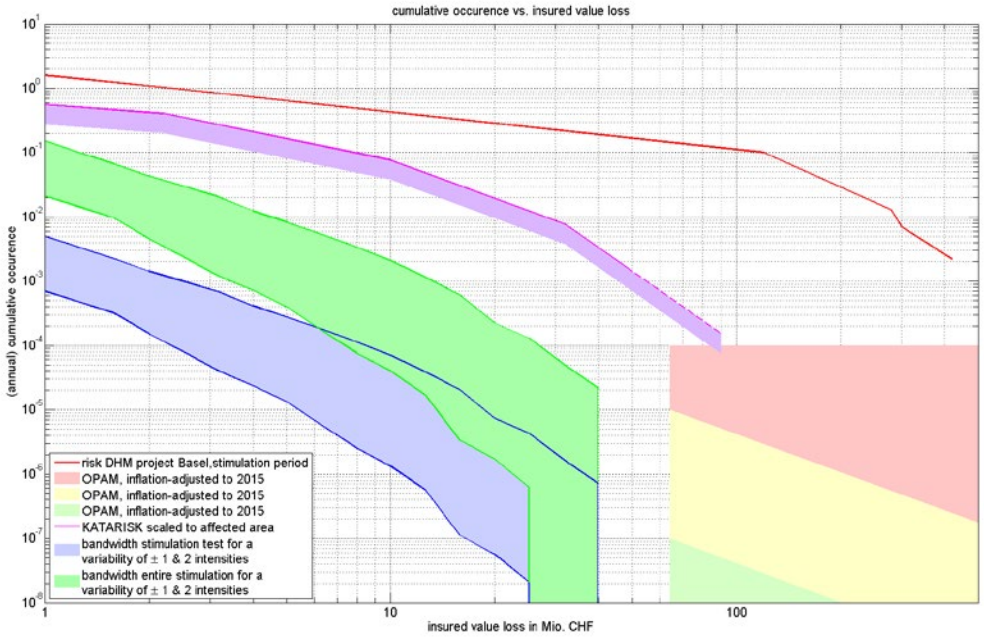

Figure 4: Comparison of risks related to induced seismicity for the pilot and demonstration project in the community of Haute-Sorne. Plotted in red is the risk related to stimulation of the Deep Heat Mining project in Basel (source SERIANEX), plotted in purple is the scaled risk of fire to according to KATARISK. Blue & green shaded areas show the bandwidth of risk for stimulation test and entire project. Upper and lower bounds show best estimates (the median of a logic tree approach[1]) presented for aleatoric variabilities of +/-1 and +/- 2 intensity units. The shaded area below KATARISK shows an adaption to data taken from BFB and the 'établissement Cantonal d'assurance immobilière et de prévention'. The risk of fire is no longer shown for losses above 90 Mio. CHF, because the distribution of valuable infrastructure (multi-floor houses, heavy industries, etc.) in the Canton of Jura is no longer represented by Swiss statistics.

[1] a detailed study on risk using a logic tree approach and a comparison to OPAM can be found in Bethmann & Zingg, 2015.

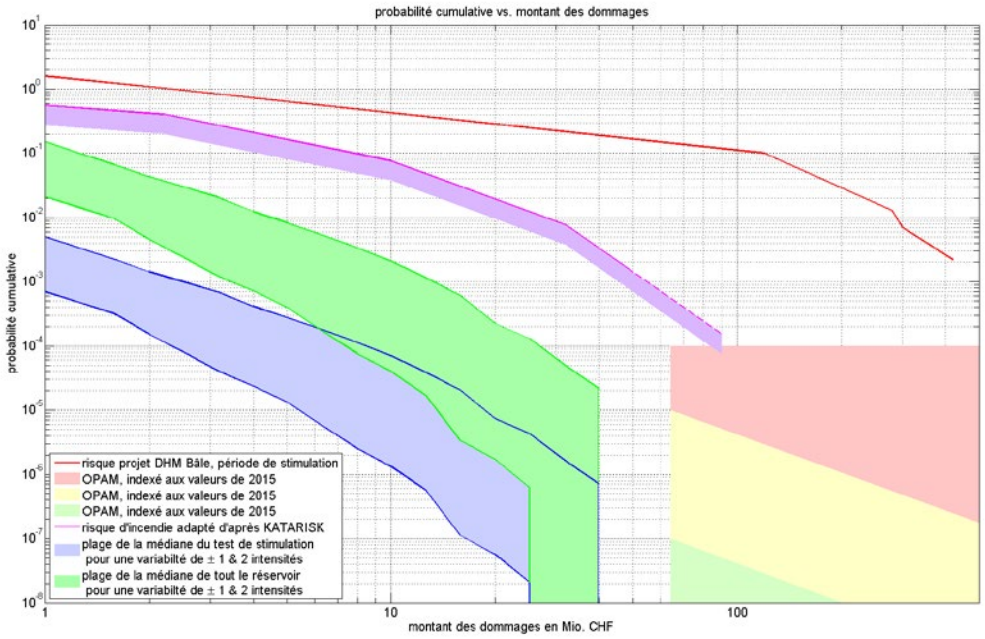

Figure 5: same as Figure 4, but with French axes.

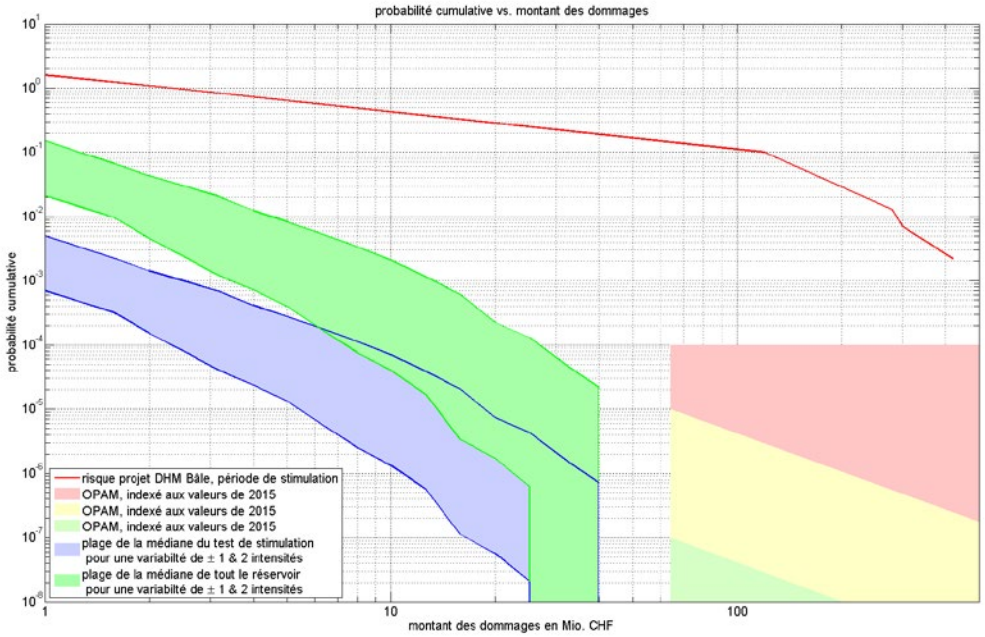

Figure 6: same as Figure 5, but without comparison to KATARISK

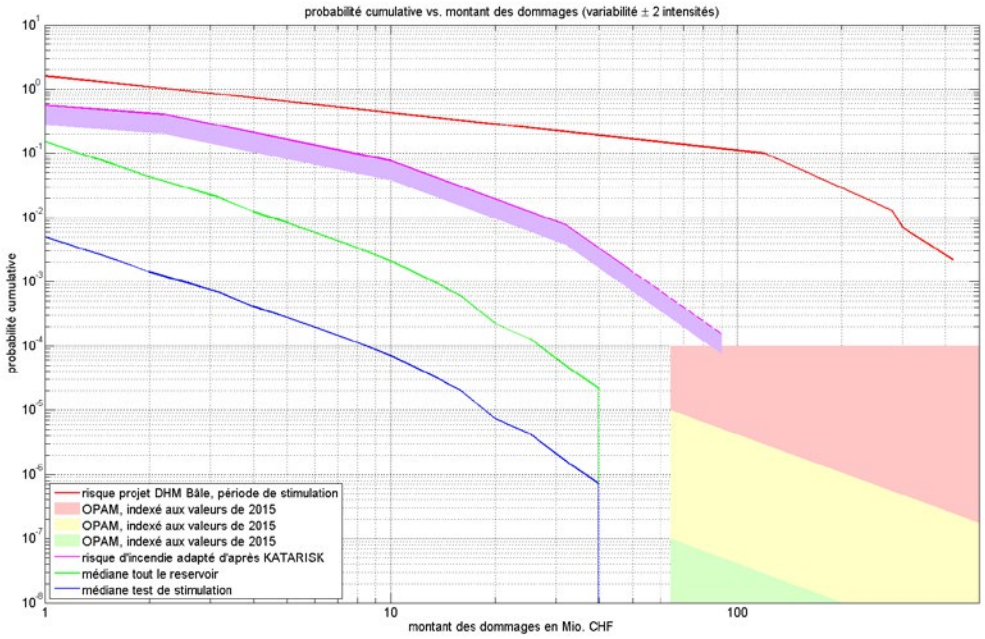

Figure 7: same as Figure 5, but only showing blue and green curve for a variability of +/- 2 intensity units

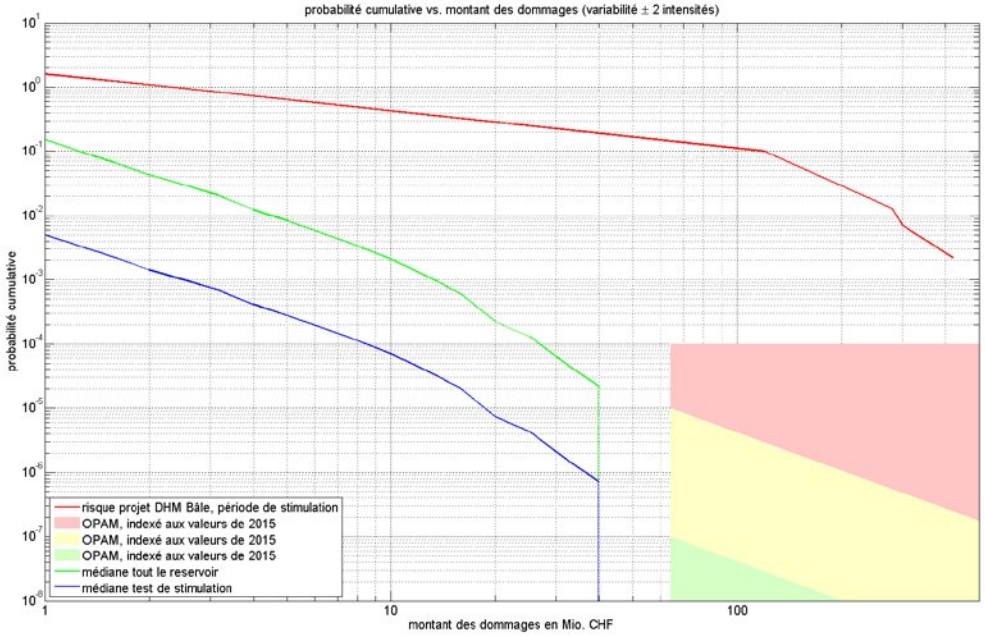

Figure 8: same as Figure 7, but without comparison to KATARISK

4 Discussion & Conclusion

Aim of this study was to compare risk of induced seismicity caused by the geothermal project in the community of Haute-Sorne to other known and in case of fire tolerated risks by the general public. In this study the risk of fire was chosen, because it is also a technical risk and is faced by every person every day. In addition the risk curve of fire has a similar shape compared to the risk curve of induced seismicity. We also present the risk curve of the Deep Heat Mining Project of Basel as presented by the SERIANEX study (Baisch,2009) for a case were the risk was considered as not acceptable.

Compared to the risk of fire, the risk of induced seismicity for Haute Sorne and surroundings is lower in terms of monetary loss. However, when both risks are compared on a monetary basis, there are further differences. When a fire incident happens, the damage to one house is usually severe. A few persons will be heavily affected and might even be harmed, but surroundings will be most likely unaffected. For induced seismicity the situation is the opposite, in case a damaging event occurs, minor damages like micro-fissures are observed over a wider area and repair cost for plastering and painting can sum up to a considerable amount, however people will most likely be unharmed and not affected at all in their daily routine. In that sense, severe impacts for one or few individuals are compared to nuisance for a larger affected community.

Summarizing, when the risk of fire is compared to the risk of induced seismicity for the stimulation of the project in Haute-Sorne, severe damages (>1 Mio. CHF) occur less often by a factor of 5-150. This calculation is based on a conservative assumption of an aleatory variability of +/- 2 intensity units and an equal weighting of logic tree branches[2]. If parameters are chosen in a less conservative manner, e.g. by using a different weighting of the logic tree or swapping to a variability of +/- 1 intensity units, the risk of induced seismicity reduces even further, to factors of 10-10’000 less than the risk of fire.

[2] A detailed description on parameter choices and weighting schemes can be found in Bethmann & Zingg, 2015

5 Literature

Alcolea, A., Bethmann, F., 2014 *Probabilistic seismic hazard analysis of a geothermal project in the Haute-Sorne community*.

Bethmann, F., Zingg, O., *Assessment of the seismic risk induced by the geothermal project of Haute-Sorne,* Technical report to the hands of the Canton Jura, 2015

Baisch, S., Carbon, D., Dannwolf, U., Delacou, B., Devaux, M., Dunand, F., Jung, R.,Koller, M., Martin, C., Sartori, M., 2009. *Deep Heat Mining Basel: Seismic RiskAnalysis*, SERIANEX Group. Departement für Wirtschaft, Soziales und Umweltdes Kantons Basel-Stadt, Basel.

Baisch, S., Vörös, R, Pulm, P., 2013, *Bewertung des seismischen Risikos durch ein EGS Projekt in der Gemeinde Haute-Sorne: Hauptuntersuchung*, Version131223, GEOS005

Douglas, J., Edwards, B., Cabrera, B. M., Convertito, V. Tramelli, A., Kraaijpoel, D., Maerck-lin, N., Sharma, N., and G. De Natale, 2013. *Predicting Ground Motion from Induced Earthquakes in Geothermal Areas*. Bull. Seism. Soc. Amer., doi:10.1785/0120120197.

KATARISK: Katastrophen und Notlagen in der Schweiz eine Risikobeurteilung aus der Sicht des Bevölkerungsschutzes
http://www.bevoelkerungsschutz.admin.ch/internet/bs/de/home/themen/gefaehrdungen-risiken/studien/katarisk.html

Appendix A - Scaling the risk of fire to the affected area of induced seismicity

The risk of fire within the KATARISK study is calculated for Switzerland. Therefore, to make risks comparable the risk of fire needs to be scaled down by the number of affected people or an area of influence of induced seismicity, respectively. If a small damaging earthquake occurs, the number of affected people and the area where damages occur is small; therefore the risk of fire is also calculated for a small area. Vice versa, in case a large earthquake occurs, more people are affected and therefore the loss of fire is scaled to a larger area. Aim is to calculate scaling factors in a conservative manner, which is in this case is to always choose parameters that lead to a low risk of fire compared to induced seismicity.

Method

Data of fire damages are given by the KATARISK study for entire Switzerland, or by the 'établissement Cantonal d'assurance immobilière et de prévention' for the Canton Jura (list see end of document).

To get the scaling factor, probability has to be set into a relation to the number of affected people or the area of influence, respectively. To do this, we pick a loss value in the probability vs. loss plot of KATARISK and link it to a magnitude via Figure 1. The magnitude then leads to a radius or area of influence using Figure 2. Using the radius, the scaling factor is determined using Equation (1):

$$\text{Scaling factor}(M) = Inh/(r_{(M)}^2 * \pi * \delta), \qquad \text{Equation (1)}$$

where M is the magnitude, r is the radius of influence, δ is the population density, and Inh is the number of inhabitants in Switzerland or Canton Jura, respectively.

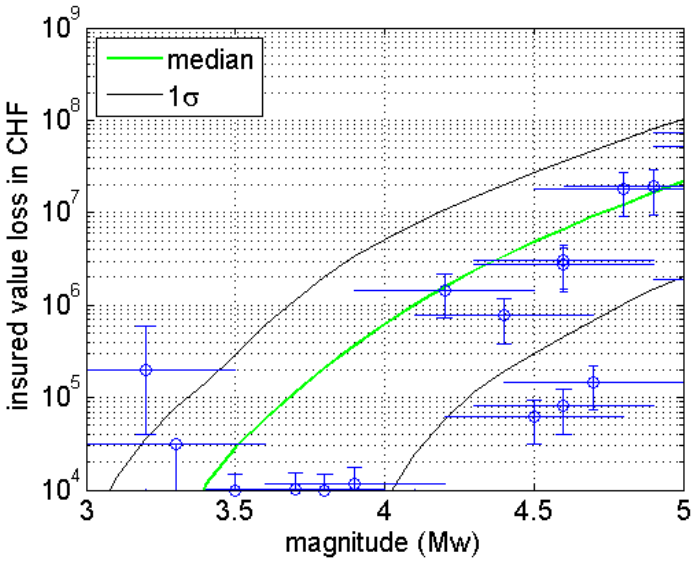

Figure 1: relation of loss vs. magnitude, the median curve or 'best estimate' is taken to link losses to magnitude. Figure taken out of the technical report handed in to the Canton Jura (Bethmann & Zingg, 2015)

The radius of influence (*r*) is defined as radius where a peak ground velocity threshold (pgv) of 5mm/s is no longer exceeded. The definition is identical to the definition of the perimeter in the Q-con deterministic risk study (Baisch, 2013). Pgv is calculated using a ground motion prediction equation of *Douglas (2013),* including surface amplification. The radius of influence is plotted in Figure 2.

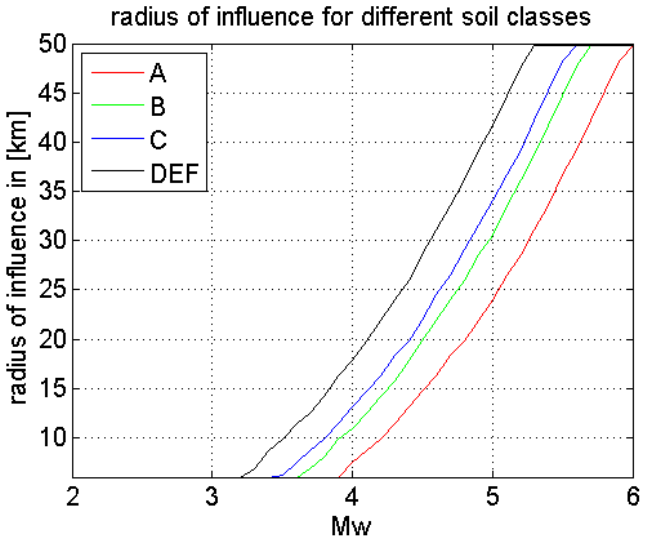

Figure 2: Radius of influence for different soil classes and magnitudes.

For simplicity the area of influence is determined using the curve for soil class ‘A’ which leads to a small affected area and therefore to a low risk of fire. Choosing a different soil class would lead to a larger area and therefore to a higher risk of fire compared to induced seismicity.

As a last step the scaling factor as a function of magnitude (Equation 1) has to be converted into a scaling factor as a function of loss. This is done using Figure 1. The risk of fire is then calculated as follows:

Scaled risk of fire= risk fire(loss) / scaling factor(loss) Equation (2)

Appendix B - List of fire damages Canton Jura

Date	city	building type	cause	Damage in CHF
02.01.2006	Seleute	Habitation, rural	Court-circuit sur véhicule ?	1'070'000.00
06.01.2006	Courrendlin	Habitation, restaurant	Poêle à bois	1'356'240.00
06.01.2006	Courrendlin	Habitation,magasin	Poêle à bois	742'556.00
26.01.2006	Delémont	Locatif	Cigarette	105'000.00
31.01.2006	Pleigne	Habitation	Résidus de combustion	375'000.00
11.02.2006	Delémont	Discothèque, bar	Intervention humaine fortuite ou délibérée	29'000.00
13.03.2006	Movelier	Habitation	Conduit de fumée	190'000.00
30.03.2006	Alle	Fabrique de boîtes de montres	Machine utilisée de manière inappropriée	290'000.00
31.05.2006	Vicques	Habitation, rural	Intervention humaine fortuite ou délibérée	30'000.00
04.06.2006	Courrendlin	Habitation	Dysfonctionnement électrique	170'000.00
24.06.2006	Porrentruy	Habitation	Incomplètement élucidée	40'000.00
05.07.2006	Delémont	Bureaux	oup de foudre	64'300.00
05.07.2006	Delémont	Institut	Coup de foudre	25'000.00
13.07.2006	Lajoux	Habitation, rural	Coup de foudre	265'000.00
13.07.2006	Lajoux	Rural	Coup de foudre	39'600.00
17.08.2006	Porrentruy	Habitation	Installations électriques défectueuses	61'000.00
12.10.2006	Courgenay	Habitation, commerces	Intervention humaine fortuite ou délibérée	490'000.00
02.11.2006	Courrendlin	Habitation	Criminelle	145'000.00
03.11.2006	Courtételle	Habitation, garage industriel	Criminelle	40'000.00
06.11.2006	Les Bois	Habitation, boulangerie	Bougie ?	85'000.00
22.12.2006	Les Breuleux	Habitation, rural	Défectuosité installation électrique	800'000.00
19.01.2007	Boncourt	Entrepôt	Canal de fumée	23'900.00
05.02.2007	Courrendlin	Habitation, commerce	Défectuosité technique ?	840'000.00
09.04.2007	Undervelier	Habitation	Machine à café défectueuse	20'000.00
30.04.2007	Bassecourt	Industrie horlogère	Installations électriques défectueuses	180'000.00
16.05.2007	Delémont	Habitation, café, commerces	Bougie	37'000.00
21.05.2007	Chevenez	Fabrique d'appareils	Coup de foudre indirect	21'600.00
31.05.2007	Courrendlin	Rural	Malveillance par un tiers	53'000.00
01.06.2007	Courrendlin	Habitation	Casserole laissée sans surveillance	315'000.00
12.06.2007	Montfaucon	Habitation	Coup de foudre indirect	25'000.00

Date	city	building type	cause	Damage in CHF
10.07.2007	Courchavon	Habitation	Appareil électrique défectueux	24'600.00
02.08.2007	Pleigne	Rural	Echauffement du fourrage	370'000.00
03.10.2007	Courrendlin	Surface commerciale	Malveillance par un tiers	64'000.00
09.10.2007	Delémont	Café	Mégot de cigarette	130'000.00
21.11.2007	Montignez	Entrepôt	Appareil utilisé de manière inappropriée	30'000.00
21.11.2007	Boécourt	Habitation	Cheminée de salon	25'000.00
29.11.2007	Saint-Ursanne	Fabrique d'appareils	Appareil défectueux	70'000.00
23.12.2007	Porrentruy	Habitation, bureaux	Enquête de police en cours	1'300'000.00
03.01.2008	Courrendlin	Habitation	Mégot de cigarette	115'000.00
11.01.2008	Chevenez	Fabrique de pompes	Défectuosité technique	25'100.00
17.01.2008	Delémont	Habitation-atelier	Appareil utilisé de manière inappropriée	46'000.00
19.01.2008	Le Noirmont	Refuge	Canal de fumée défectueux	26'000.00
26.01.2008	Delémont	Habitation	Briquet	210'900.00
15.02.2008	Delémont	Habitation	Installations électriques défectueuses	34'500.00
07.03.2008	Bourrignon	Rural	Cause incomplètement élucidée	945'000.00
08.04.2008	Bassecourt	Habitation	Dysfonctionnement électrique	175'000.00
01.06.2008	Delémont	Habitation-restaurant	Défectuosité appareil TV	130'000.00
10.06.2008	Courrendlin	Habitation	Intervention humaine ?	34'000.00
30.06.2008	Delémont	Habitation	Malveillance par des inconnus	118'400.00
14.07.2008	Courrendlin	Habitation	Incendie intentionnel ou par négligence	45'000.00
15.08.2008	Pleigne Dépôt, local	chauffage	Appareil utilisé de manière inappropriée	38'000.00
02.09.2008	Delémont	Habitation	Casserolle laissée sans surveillance	27'400.00
16.09.2008	Porrentruy	Habitation-scierie	Intervention humaine délibérée ou fortuite	335'000.00
28.09.2008	Coeuve	Habitation	Résidus de combustion	225'000.00
05.10.2008	Courtételle	Habitation-restaurant	Casserolle laissée sans surveillance	26'000.00
18.10.2008	Delémont	Habitation-restaurant	Casserolle laissée sans surveillance	800'000.00
18.10.2008	Delémont	Habitation-magasin	Casserolle laissée sans surveillance	30'000.00
25.12.2008	Les Breuleux	Habitation-dépôt	Casserolle laissée sans surveillance	60'000.00
27.12.2008	Saignelégier	Habitation	Bougie	60'000.00
31.12.2008	Porrentruy	Habitation	Casserolle laissée sans surveillance	65'000.00
15.01.2009	Grandfontaine	Habitation	Cheminée défectueuse	75'000.00

Date	city	building type	cause	Damage in CHF
10.02.2009	Delémont	Rural	Feu de cheminée	31'000.00
16.03.2009	Courtételle	Habitation	Défaut de construction de la cheminée française	190'000.00
03.04.2009	Alle	Fabrique de textiles	Défectuosité technique d'un moteur	45'400.00
14.05.2009	Courfaivre	Fabrique	Travaux de soudage	210'000.00
21.05.2009	Delémont	Atelier de décolletage	Déversement accidentel de benzine	54'100.00
16.06.2009	Courroux	Habitation	Appareil défectueux	60'000.00
30.06.2009	Alle	Habitation	Incendie volontaire d'une voiture	210'000.00
08.08.2009	Chevenez	Habitation	Cigarette ?	295'000.00
27.08.2009	Saint-Ursanne	Fabrique de matrices	Dysfonctionnement électrique ?	100'000.00
12.09.2009	Courgenay	Habitation	Cause incomplètement élucidée	450'000.00
24.09.2009	Delémont	Atelier de décolletage	Usage inapproprié de benzine	23'000.00
16.10.2009	Soubey	Rural	Défaut de construction de la cheminée	80'000.00
30.10.2009	Courgenay	Habitation	Accidentelle ?	180'000.00
10.03.2010	Montignez	Habitation avec rural	Chauffage électrique qui a bouté le feu à une bouillotte	55'000.00
12.05.2010	Delémont	Restaurant	Dysfonctionnement du sèche-linge	730'000.00
20.05.2010	Delémont	Habitation-locaux artisanaux	Petit enfant jouant avec un briquet	120'000.00
04.06.2010	Vicques	Habitation	Usage inapproprié d'un radiateur électrique	36'000.00
30.08.2010	Delémont	Habitation	Incendie du corps de chauffe du boiler	65'000.00
09.10.2010	Les Genevez	Habitation	Début d'incendie du chauffe-eau	25'000.00
07.11.2010	Bure	Habitation	Incendie par la cheminée de salon	280'000.00
03.12.2010	Vendlincourt	Habitation	Défaut de construction de la cheminée ?	350'000.00
04.12.2010	Develier	Habitation avec rural	Défectuosité du fourneau à banc	230'000.00
01.01.2011	Courtételle	Habitation avec rural	Incendie par négligence	465'000.00
22.01.2011	Porrentruy	Centrale de chauffage à distance	Particules incandescentes qui ont bouté le feu	135'000.00
20.02.2011	Vicques	Habitation à deux logements	Cause accidentelle, enclencher plaque de cuisson	27'000.00
26.02.2011	Courtedoux	Habitation P	laquette de soufre tombée sur des matériaux combustibles	43'300.00
23.03.2011	Bressaucourt	Habitation	Mégot de cigarette	100'000.00
24.03.2011	Bonfol	Rural	Négligence d'un enfant	430'000.00

Date	city	building type	cause	Damage in CHF
28.03.2011	Montsevelier	Ecurie-remise-fenil	Intervention humaine fortuite ou délibérée	76'000.00
08.04.2011	Cornol	Garage auto désaffecté, bureaux	Explosion d'une bombonne de gaz	105'000.00
29.04.2011	Courrendlin	Centrale production électricité	Coup de foudre	58'320.00
12.06.2011	Charmoille	Remise à machines agricoles	Défectuosité hotte d'une chaudière à bois	95'000.00
22.06.2011	Vicques	Habitation	Coup de foudre	28'000.00
28.06.2011	Delémont	Habitation, bureau, salon coiffure	Mégot de cigarette	37'000.00
12.07.2011	Cornol	Stabulation chevaux	Coup de foudre	155'000.00
09.08.2011	Les Enfers	Habitation avec rural	Intervention humaine fortuite	75'000.00
18.08.2011	Delémont	Habitation-locaux commerciaux	Mégot de cigarette	165'000.00
08.10.2011	Bonfol	Habitation	Défaut de construction sur cheminée de salon	177'752.00
21.11.2011	Les Pommerats	Habitation, dépôt	Mégot de cigarette	50'000.00
07.01.2012	Glovelier	Maison d'habitation	Défaut de construction sur tuyau de fumée	365'000.00
21.01.2012	Lugnez	Maison d'habitation	Combustion de cendres dans un aspirateur	31'000.00
27.01.2012	Saignelégier	Pavillon-vestiaires	Dysfonctionnement d'origine électrique	115'000.00
02.02.2012	Porrentruy	Habitation-commerce	Mégot de cigarette	21'000.00
06.02.2012	Saint-Ursanne	Fabrique de pièces matrices	Explosion	400'000.00
08.02.2012	Les Breuleux	Parqueterie	Explosion	50'000.00
09.02.2012	Develier	Habitation-rural	Dysfonctionnement d'origine électrique	40'000.00
11.02.2012	Boécourt	Maison d'habitation	Défaut de construction du canal de cheminée de salon	80'000.00
22.05.2012	Bonfol	Maison d'habitation	Lave-linge qui a pris feu	42'000.00
02.06.2012	Coeuve	Maison d'habitation	Dysfonctionnement d'origine électrique	480'000.00
18.06.2012	Courgenay	Rural	Fermentation de fourrage	230'000.00
06.07.2012	Lajoux	Habitation-atelier mécanique	Cause incomplètement élucidée	715'000.00
19.07.2012	Porrentruy	Halle-remise	Cause incomplètement élucidée	125'000.00
12.08.2012	Vicques	Maison d'habitation	Probable intervention humaine	260'000.00
09.09.2012	Le Noirmont	Habitation-rural	Cause incomplètement élucidée	1'160'000.00
18.10.2012	Courgenay	Habitation-rural désaffecté	Cause incomplètement élucidée	200'000.00
18.10.2012	Courgenay	Maison d'habitation	Sinistre du bâtiment voisin	30'000.00

Date	city	building type	cause	Damage in CHF
19.10.2012	Les Breuleux	Habitation-dépôt	Incendie intentionnel	350'000.00
24.10.2012	Saint-Ursanne	Usine de matriçage à chaud	Incendie par négligence	300'000.00
25.11.2012	Coeuve	Habitation-dépôt	Appareil électrique défectueux	30'000.00
01.01.2013	Undervelier	Entrepôt	Certainement auto-inflammation d'huile de lin	150'000.00
29.01.2013	Saignelégier	Atelier de mécanique	Meulage de pièces métalliques à proximité de titane	25'000.00
12.04.2013	Damphreux	Atelier de mécanique	Dysfonctionnement d'origine électrique	45'000.00
10.06.2013	Courroux	Maison d'habitation	Incendie des corps de chauffe du chauffage	32'000.00
14.08.2013	Courfaivre	Remise-carnotzet	Incendie dans la cheminée de salon	35'000.00
26.08.2013	Le Noirmont	Rucher	Combustion lente de cadres de ruches	29'000.00
01.09.2013	Fahy	Maison d'habitation,presbytère	Dysfonctionnement d'origine électrique dans une hotte	35'000.00
11.11.2013	Courfaivre	Maison d'habitation	Transfert de chaleur entre le canal cheminée et chevron	50'000.00
13.12.2013	Vermes	Maison d'habitation et atelier	Combustion lente de cendres chaudes	50'000.00
22.12.2013	Rossemaison	Habitation-rural	Chauffage central	25'000.00
31.12.2013	Montignez	Hangar agricole	Mégot de cigarette	130'000.00